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ENERGY AND PRODUCTIVITY
IMPLICATIONS FOR REAL INCOME AND INFLATION

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ABSTRACT

Falling productivity growth over recent years has become one of the nation's foremost economic problems. This paper examines some possible causes, and concludes that, since 1973, rising energy prices have been responsible for most of the productivity growth decline. The paper also assesses the negative impact of past energy price increases on the rate of inflation in the U.S. It concludes with discussions of the outlook for future productivity and energy prices and suggests appropriate policy responses such as incentive schemes and relaxation of regulatory practices.

INTRODUCTION

During the first half of the 1970's, most people considered inflation to be the nation's number one economic problem. While inflation still remains a major concern as we move into the 1980's, it is rapidly being replaced by an even greater problem--falling productivity growth. Even with inflation, it is possible to increase the nation's real standard of living, but this is not the case to any significant degree without an increase in productivity.

After World War II, productivity and the standard of living of North America and the other major industrialized countries grew rapidly. During the 1950's and 1960's, natural resource prices were usually either constant or slightly falling in real terms, and, particularly in the U. S., the technological base expanded significantly because of large commitments to research and development. Since the mid-1960's, Europe and Japan have expanded their own R&D programs to help close the technological gap between the U.S. and other major industrialized nations. With the rapid rate of growth of technology and productivity, people in the western world have come to expect a continually rising growth rate in the standard of living bringing more wealth, leisure time, mobility, and a better quality of life. In all western nations, people have also come to expect that the increased growth rate of the living standard will be passed on to future generations.

However, expectations of an ever-increasing standard of living among nations began to fall in the mid-1970's with the quadrupling in world petroleum prices between 1973 and 1974. Between 1973 and 1978, productivity growth has been cut in half in the United States and all other major western industrialized countries. Today, productivity growth in the United States is so low that many economists are seriously questioning whether this nation can increase or even maintain its existing living standard.

This paper argues that the major reason for the fall in productivity growth, and hence the rate of increase in the standard of living, or real income per person, is the cost of energy. It assesses the falling productivity growth caused by rising energy prices, speculates on the movement of energy prices between now and 1985, and suggests the implications for productivity growth and economic welfare. It also considers some errors that have crept into the published literature and added much unnecessary confusion to the productivity issue. Finally, analyzes the impact of energy prices on inflation.[*]

HISTORICAL PERSPECTIVE

Labor productivity in the U.S. private business sector has gone through three distinct phases in the post WW II period. During the years 1948-65, labor productivity grew at the rapid pace of 3.2% per year (Table 1). Over these years energy prices were relatively constant in real terms, and research and development expenditures (constant dollars) increased at a rate of approximately 2% per year. Betweeen 1965 and 1974, productivity growth in the private business sector slowed to an annual rate of 2.2%.

Several studies have attempted to explain the drop in productivity over this period. For example, Clark[1] found a slight effect on productivity from

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[*]To carry out the analysis, I use an aggregate production function developed by Tatom and Rasche (see Ref. 6). An aggregate production function is simply a mathematical relationship between real GNP and the factors used to produce it, viz., capital (i.e., machines, buildings, and land), labor and energy.

Between 1973 and 1978 labor productivity growth took another major fall to 1.1% per year. However, unlike the two previous periods, rising energy prices played a major role. In the early 1970's energy prices rose gradually in the U.S. and then jumped by about 50% in real terms in 1974 (Fig. 1). The large increase in energy prices resulted in a supply side shock that played a major role in producing the worst recession since the 1930's depression, and was, perhaps, the most important factor in causing the drop in productivity growth over the 1973-78 period. As explained below, about 30% of the fall in labor productivity growth is due to the direct effect of energy prices on the growth of real U.S. private output. Higher energy prices have a further indirect impact on productivity growth by inducing a reduction in capital investment.

As Tatom[4] pointed out, when energy prices go up in real terms, the price of business output is raised, the capacity of the business sector is reduced because some equipment becomes obsolete, and output falls, thus reducing the productivity of labor. While estimates are admittedly crude, our best estimate is that labor productivity was reduced by about 4-5% during the 1974-75 recession because of the energy problem. If, after the downward shock to the GNP, energy prices had remained constant in real terms, then productivity would have continued to grow at roughly its historical rate before the energy price increase, but on a lower growth path. However, energy prices in the U.S. kept on rising in real terms, which significantly reduced the growth of labor productivity between 1973 and 1978.

Higher energy prices and resulting efforts to economize on energy use have reduced both the level and growth of the GNP. Increased energy prices have also lowered the return on capital relative to the cost of capital; that is, the value of capital in place is lowered relative to its replacement cost. The increase in energy prices combined with the increase in the real price of capital goods has resulted in a substitution of labor for both capital and energy. To some extent, this explains why employment grew more rapidly in the post 1974-75 recession despite its severity,* than in

*Another factor to consider is the impact of energy prices on real wealth and on the response of the labor force. Clearly, the lowering of real wealth due to energy prices has caused some substitution of work for leisure in the labor force and also some increase in the participation rate.

TABLE 1. Growth of productivity and contributions from determinants over selected full employment periods.

	1948-65	1965-73	1973-78
Labor productivity	3.2	2.2	1.1
	--	--	--
Capital/ manhours	+1.2	+0.9	+0.2
Real price of energy	-0.0	-0.0	-1.2
Technical change	2.0	1.3	2.1

Source: U.S. Bureau of Economic Analysis and Bureau of Labor Statistics.

the slowdown in the movement of resources from the farm to the non-farm sector. Other economists, such as Denison,[2] have attributed the slowdown after 1965 to such factors as shifts away from manufacturing and toward a service economy, increased regulation of the economy from OSHEA and EPA, and changes in the composition of the labor force toward more unskilled workers due to increased participation rates from women and teenagers. Some investigators have attributed the fall in productivity growth over this period to a dramatic fall in the growth of R&D expenditures. In constant dollars, R&D expenditures fell in absolute terms after 1967 and did not regain the 1967 level until 1977. Real energy prices continued to remain relatively constant between 1965 and 1973. Although the dramatic fall in the growth rate of R&D expenditures appears to be one of the most plausible reasons for the fall in productivity growth between 1965 and 1973, economists disagree about causes of the falling growth rate of productivity over this period.*

*For an analysis that gives support to the R&D explanation for falling productivity growth, see the study by Cooper and Vanderford.[3]

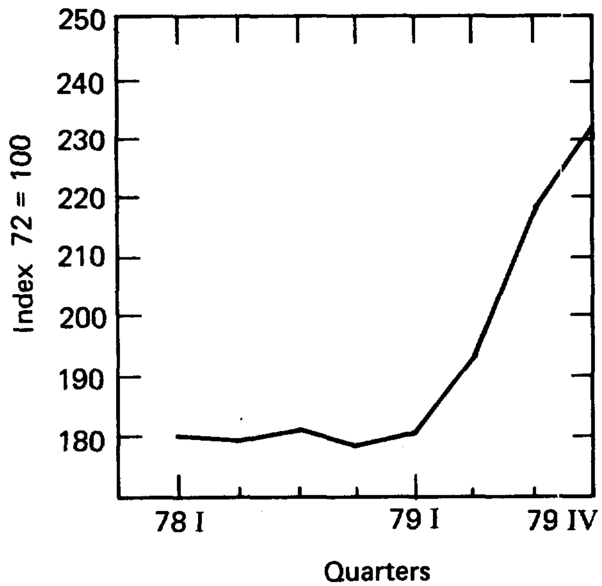

FIG. 1. Relative price of energy-the producer price index of fuels, power, and related products divided by the implicit price deflator for the private business sector. Sources are the U.S. Department of Labor, the U.S. Department of Commerce, and the Federal Reserve Bank of St. Louis.

previous ones. Table 1 shows that there was a major reduction in the growth of capital input per man-hour which did not occur over full employment periods prior to 1973. For example, the growth of capital input per man-hour per year during 1948-65 was 4.1% and 3.0% during 1965-73 (see Table 1), while it fell to 0.6% per year during 1973-78.

A DISCUSSION OF THE ENERGY PRODUCTIVITY CONTROVERSY

In two recent papers, Denison[2] has confused the productivity issue greatly by making fundamental errors in his analysis. First, Denison finds little or no fall in productivity growth after 1973 due to a slowdown in capital input per worker. The reason is that Denison compares the growth of capital per worker (he uses the term "worker" rather than "man-hour") over a full employment period (1948-73) with a non-full employment period (1973-76). In 1976 there was substantial excess capacity in the U.S. economy and the large impact on productivity resulting from the fall in the growth of the capital/man-hour ratio after 1973 does not become apparent until the full employment year 1978 is included.

Denison's other error is that he dismisses the direct impact on output and productivity from the increase in energy prices. He bases his conclusion on an earlier study by Perry of the Brookings Institution.[5] In his study, Perry rejects the Rasche-Tatom[5] results for the U.S. because they assume that the own price elasticity of demand for energy is unity. From his examination of U.S. energy consumption data after 1973, Perry concludes that the own price elasticity of the demand for energy must be much less than unity, and Rasche and Tatom therefore, overstate the importance of energy. However, Perry fails to recognize that a lower estimate of the price elasticity for energy than the value (unity) assumed by Rasche-Tatom[6] <u>increases</u> rather than decreases the impact of energy price changes on real aggregate output. If we look at the growth rate of gross energy consumption for the industrial sector, and the rate of growth of energy prices over the 1973-78 period, we find an implied price elasticity of about 0.5 which is somewhat lower than the value assumed by Rasche-Tatom.[6] If the lower value is correct, then energy has a bigger impact on the economy than that found by Rasche-Tatom. Thus, when Denison's errors are corrected, we find that rising energy prices and a falling capital/labor ratio can account for essentially all of the fall in productivity growth after 1973.

The only uncertainty that does exist concerns an explanation for the behavior of the capital/labor ratio since 1973. The growth of the U.S. capital/labor ratio fell from 3.0% per year between 1965 and 1973 to 0.6% per year from 1973 to 1978. Several studies attributed the fall in capital investment to a decrease in the rate return on capital due to the tax treatment of depreciation, on an historical rather than a replacement cost basis.[7] However, recently published articles by Modigliani and Cohn[8] have dispelled this argument by showing that the after-tax rate of return on capital does not fall as significantly when proper accounting procedures are used. As Modigliani and Cohn point out, the reason that earlier studies on investment show a much lower return on capital is that they adjusted assets for inflation, but failed to adjust liabilities. Firms can partly offset the depreciation of their fixed real assets by issuing more debt, which is precisely what has happened during the 1970's when inflation rates were higher than in previous years.

Also, because of fixed contracts for labor, output prices tend to increase at a faster rate than input prices thus preserving the rate of return on capital during inflationary periods. As pointed out in a study by Kim[9], the disparity between the growth of output and input prices tends to preserve net operating income which offsets the inflationary effects of depreciation on capital investment. Thus, since there are both positive and negative influences in the return to capital resulting from inflation, it is an empirical rather than a theoretical question as to whether inflation has a negative or a positive influence on the rate of capital investment. The empirical evidence suggests that nonresidential fixed investment is <u>positively</u> rather than negatively correlated with the rate of inflation.

Some investigators have argued that the increase in the variability of inflation, rather than the higher expected rate of inflation is responsible for the retardation in the rate of capital investment since 1973. However, because the rate of inflation has a positive rather than a negative effect on investment, it is unlikely that uncertainty about future inflation has had any significant effect in reducing the rate of capital investment. Then what did cause the decline in investment growth between 1973 and 1978?

Although we do not have a complete answer to this question, I believe that the fall in capital input per worker after 1973 is due largely to the rise in energy prices. When the price of energy increases, the price of new capital goods increases more than on goods and services in the rest of the economy (Star).[10] The reason for this is that the production of capital goods is more energy intensive than the production of output in the non-capital goods sector.

Using an historically derived relationship between the growth rate of energy prices and the price of new capital goods, we find that a 10% increase in the price of energy is associated with about a 1% increase in the price of capital goods. In 1974, the price of energy, in real terms, rose by about 50% in the U.S., while the price of capital goods in real terms rose between 5% and 10%, which agrees with our historically determined relationship between energy and capital goods. The increase in the real supply price of capital goods slows down the rate of capital investment by lowering the return on capital investment relative to the cost of capital. However, there is a further reduction in the return on capital investment from higher energy prices due to the higher operating costs for new capital goods. When both of these effects are taken into account, it seems quite plausible that the rise in energy prices between 1973 and 1978 can explain all or at least a substantial part of the slowing in the rate of capital accumulation. Comparing the recent with the more distant past, we find that for the years 1948-73 net capital accumulation accrued at a rate in excess of 4%, while during 1973-78 it fell to less than 3% per year.

PRODUCTIVITY AND REAL INCOME

There is a close relationship between labor productivity and real income per worker (Fig 2). If real energy prices had remained constant between 1973-78, we could calculate the impact on productivity and real income. From the direct impact of energy prices on output we find in Table 2, that according to our simple model productivity would have grown at 2.3% per year between 1973 and 1978, had real energy prices remained constant over this period. If we further assume that all of the fall in the growth of the capital/labor ratio was due to energy price increases, then according to our model, productivity would have grown at 3.0% per year, which is essentially the same as its historical rate over the period 1948-73. If, on the other hand, rising energy prices were responsible for only 25% of the fall in the growth of the capital/labor ratio, then, with constant energy prices, productivity would have grown at 2.5% per year during 1973-78.

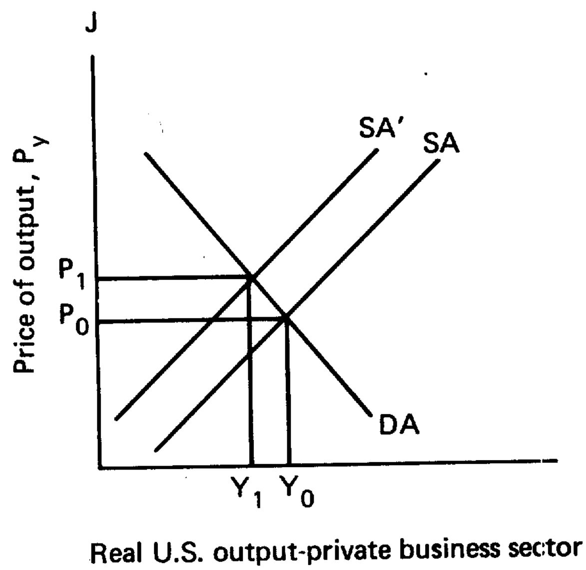

FIG. 2. Aggregate price level and output.

TABLE 2. Actual and hypothetical values of productivity growth rates based on alternative assumptions regarding energy prices and capital/labor ratios.

Productivity growth	1948-73	1973-78	Loss in 1978 of real compensation per employee (1972$)
Actual	2.9	+1.1	$1,330
Constant energy prices	--	+2.3	502
Historical growth of K/L (1965-73)	--	+3.0	--
75% of fall in K/L due to energy	--	+2.8	145
50% of fall in K/L due to energy	--	+2.7	217
25% of fall in K/L due to energy	--	+2.5	360

Using the historical relationship between real compensation per employee to hours worked per person and productivity, the loss in productivity growth due to the increase in the price of energy can be translated directly into a loss in real income per employee in the U.S. private business sector. We calculate that every employee took an average real loss of about $1300 (1972 dollars) in 1978, as shown in Table 2. If energy prices had remained constant between 1973 and 1978 and none of the fall in the capital/labor ratio was due to energy, then each employee sustained an average real loss in 1978 of about $500. Table 2 also shows the average loss per employee for alternative assumptions regarding the importance of energy in the fall in the capital/labor ratio. For example, if energy prices accounted for 75% of the fall in K/L growth, then the average loss for constant energy prices would have been only about $150, while energy accounting for only 25% of the fall in the growth of K/L, would have generated a somewhat larger loss amounting to about $350 per employee. In summary, I believe that rising energy prices have played a major role in dramatically slowing the growth of real income since the early 1970's.

ENERGY AND INFLATION

While there are still a few dissenters, most economists agree that inflation (defined as a sustained rise in the general level of prices) is primarily a monetary phenomenon (see Karnosky).[11] Any good student of price theory immediately rejects the notion that the price of any single commodity, such as oil, can be responsible for inflation over anything but a transitory period, unless increases in this commodity occur repeatedly over time. Accepting the monetarist view of inflation, the only way that energy prices can affect the rate of inflation is by lowering the growth of future output with an unchanged monetary policy. If, when energy prices rise in the U.S., the Federal Reserve were to reduce money growth sufficiently, then the impact of energy prices on inflation could be neutralized. Thus, the inflationary impact of energy prices depends on the amount by which the growth of output is reduced, and the response of the monetary authority. Using quarterly time series data relating the rate of inflation (growth rate of GNP deflator) to past rates of change in money and real energy prices, I have calculated, in Table 3, the net impact of energy prices on the rate of inflation between 1973 and 1978. The average inflation rate over the 1973-78 period was 7.5% per year, and of this amount, we find that 80% was monetarily determined and 13% energy determined. Energy will contribute to inflation in the future only if real energy prices continue to rise without being fully offset by a tighter monetary policy.

TABLE 3. The contribution to inflation from money and energy.

	1973-1978	
	Annual	percent change
GNP deflator	7.5	100
Contribution from:		
Money growth	6.0	80
Energy prices	1.0	13
Residual	0.5	7

THE FUTURE

During 1978 real energy prices remained relatively constant, but in 1979 the Iranian crisis triggered another major increase in world oil prices which generated about a 30% increase in U.S. real energy prices during 1979 (see Fig. 3). If our past estimates relating energy to the economy are reasonably accurate, the jump in energy prices by itself would have reduced the real U.S. GNP in the latter part of 1979 by about 3%. However, the reason that a recession was not experienced during 1979, as was the case during 1974-75, can be explained by the totally different monetary policies pursued during the two periods. During 1974-75 U.S. monetary policy became significantly tighter which immediately followed the quantum jump in energy prices, while no significant tightening in monetary policy has occurred during 1979.*

How far oil prices will rise during 1980 is not known at this time with any degree of certainty, so we shall have to wait and see whether further energy shocks occur. The outlook for stable energy prices over the next five to ten years is highly uncertain but seems unlikely because of political instability among OPEC countries and the clumsiness in which they manage oil production. Deregulating oil and gas prices in the U.S. would significantly reduce the dependence of the U.S. on OPEC oil by stimulating domestic production and encouraging more conservation, which would put downward pressure on world oil prices. However, many members of Congress take the position that, because of the alleged monopoly power of the oil and gas companies, energy prices should never be deregulated. However, these people fail to recognize the fact that the OPEC nations have taken control of the bulk of the internationally traded oil away from the oil companies during the 1970's, which has altered their role from suppliers to purchasers of oil. Before 1970 the planned production for OPEC countries by private companies was at least 50% greater than today. In Saudi Arabia alone, the

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*While the old M1 series does show a significant reduction in money growth during the latter half of 1979, no significant drop in the revised M1B series (the revised series includes nonbank checking accounts) has been observed.

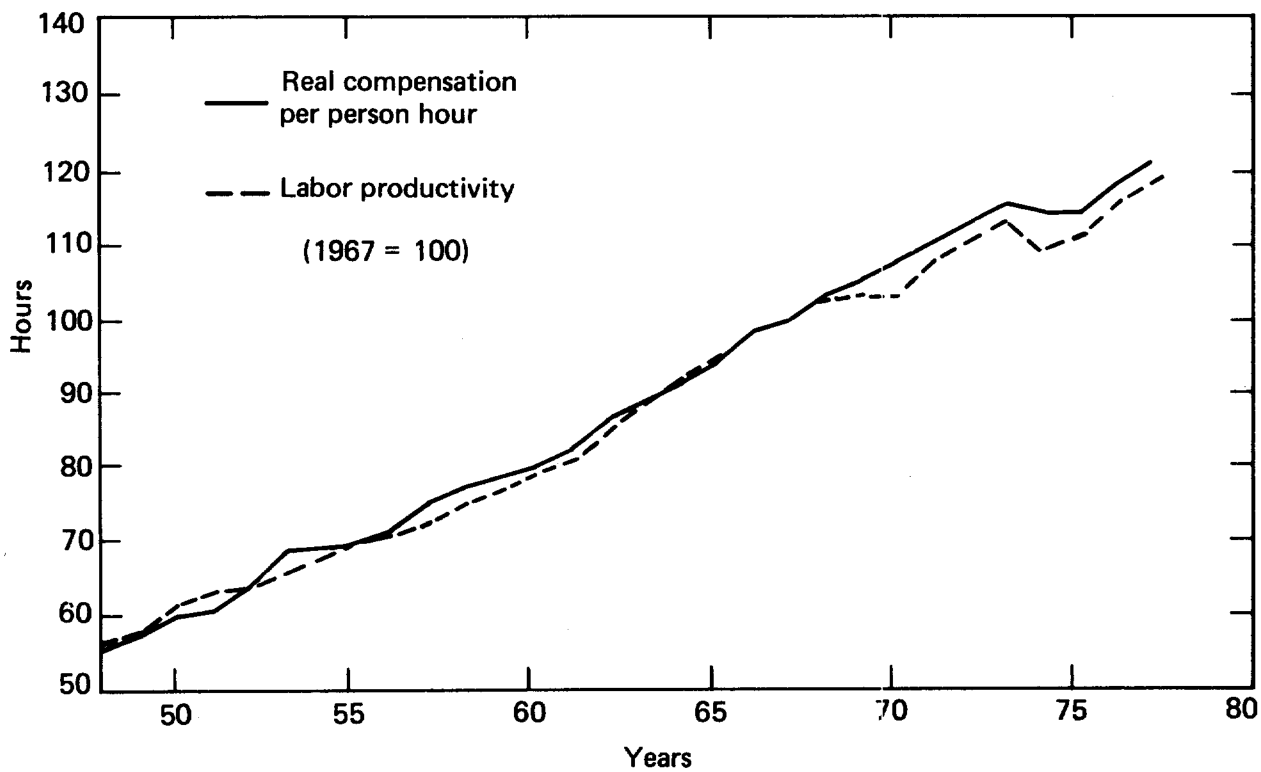

FIG. 3. Income per hour and labor productivity 1978-79.

private oil companies had planned to be producing between 15 and 20 million barrels per day, while the actual production in this country is currently around 9 million barrels per day. New oil development in the non-OPEC areas of the Free World does not look promising because of a lack of incentive by most governments and the possibility of expropriation after the oil is developed.

Most oil experts now agree that, because the individual OPEC countries have different interests from the private oil companies who originally developed their oil, OPEC oil production is very unlikely to rise in the future above current production levels, and it is likely to fall in the future to protect the real price increases already achieved. This fact combined with the confiscatory policies of the U.S. and other countries toward energy development by private industry, suggests that world oil prices, in real terms, will continue to increase (albeit at a very uneven rate) in the future.

Since the rate at which energy prices will increase is unknown, our simple model calculates an approximate tradeoff between the growth of real energy prices and the nation's living standard reflected in terms of productivity growth; which is shown in Fig. 4. One major economic consulting firm is currently projecting that energy prices in real terms will grow by about 10% between 1978 (a year of stable energy prices) and 1985, which, according to our model, implies a growth in productivity of about 1% per year. If energy prices grow at 16%, then our model implies that the nation's standard of living will fail to increase at all over the 1978-85 period. On the other hand, if, in some miraculous way, energy prices remain constant over this period, then productivity will grow at a rate of about 2.6% per year. This rate of productivity growth is not far below historical rates achieved before 1973 when the energy crisis began.

GOVERNMENT POLICY ON PRODUCTIVITY AND ENERGY

Many suggestions have been made both within and outside government regarding the solution to the nation's lagging productivity problem. For example, special commissions have been set up by the President to study the causes of the productivity problem in the U.S. Most of the studies have focused on the lack of proper government incentives to stimulate innovations by the private sector. Under the U.S. Department of Commerce, a new office has been set up for the specific purpose of promoting innovations in private industry, and the budget of NSF has been significantly increased for the next

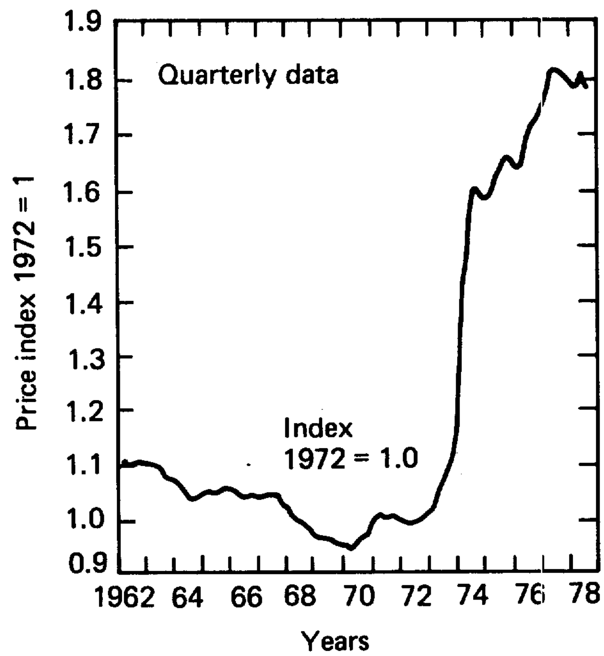

FIG. 4. Relative price of energy-quarterly data. Sources are the U.S. Department of Commerce and the U.S. Department of Labor.

fiscal year. While an analysis of recent government activities to stimulate innovation and productivity is beyond the scope of this paper, I believe that much effort has been misdirected because of failure to recognize the major cause of our productivity problem--energy.

CONCLUSIONS

Government policy on energy has been contradictory. While punishing our own oil and gas companies with excessive regulation on prices, profit margins, and excess profit taxes, which results in an inefficient and emasculated energy industry, we, at the same time, propose grandiose schemes to spend between $200 and $400 billion on subsidies for the development of synthetic fuels. Similar regulatory policies are followed in other industrialized countries, such as Canada and Australia. To regulate our energy industry, the U.S. government has massed a large government bureaucracy which sets maximum prices on fuels, regulates profit margins, etc. While it is probably unlikely to occur, the best policy for the U.S. government to follow would be to abolish the regulatory agencies of the U.S. Department of Energy (with a savings of several billion dollars to taxpayers) and allow the private energy companies to respond to OPEC by bringing on increased energy supplies from new sources. This would eventually lead to a stabilization of world oil prices, and a return to high productivity growth in the western world.

APPENDIX A

NOTES ON THE DERIVATION OF AN AGGREGATE PRODUCTION FUNCTION.

An aggregate production function is a function relating real GNP to its factor inputs -- labor, capital, and energy, i.e.

GNP B = F { CAPITAL, LABOR, PRICE OF ENERGY } + TECHNICAL CHANGE

REAL GROSS NATIONAL PRODUCT

FUNCTION

FACTOR INPUTS

Using an approximation to the aggregate production function developed by Cobb and Poughes, we can estimate F using time series data for the U.S. private economy. In estimating our production function we use the following definitions for the factor inputs.

CAPITAL =	is the stock of capital in 1972 dollars adjusted by a capacity utilization factor.
LABOR =	total man-hours worked in the U.S. private business sector per period
PRICE OF = ENERGY	wholesale price index of fuels deflated by the real private GNP price index.

The form of the production function based on the empirical studies done by Zarenbka,[12] Walters,[13] and Douglas[14] has been determined to be a good approximation of the aggregate production function for the U.S. economy. For a more technical and more complete discussion of the aggregate, see the articles by Rasche and Tatum.[6]

Once the aggregate production function is estimated, we can determine the relative importance of labor, capital, and energy in explaining real GNP. Based on our aggregate production function, the share of GNP devoted to each factor input is given as follows:

FACTOR INPUTS	RELATIVE OUTPUT SHARE (%)
Labor	65
Capital	25
Energy	10

The contribution of each factor input to the growth rate of real output for a given period can be calculated by multiplying its relative output show times its own growth rate over the same period.

The aggregate production function can be rearranged to express labor productivity (which is of particular interest in this paper) as a function of capital input per unit of labor, the price of energy, and the rate of technological change. The model expressed in this form is used to generate different growth rates of labor productivity under alternative assumptions regarding capital investment and the growth of real energy prices. In our analysis in this paper, we focus on labor productivity as an approximation to total factor productivity. Economists generally prefer to speak in terms of total factor productivity, i.e., all factors combined, rather than the productivity of a specific input, since the former is a more meaningful concept in terms of neoclassical economic theory. However, from a practical sense, since labor is by far the most dominant factor input in the production of the GNP, labor productivity growth provides a very close approximation to the growth of total factor productivity. In addition, "labor productivity" is a term which is familiar to non-economists as well as economists, while "total factor productivity" is a less well known concept.

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